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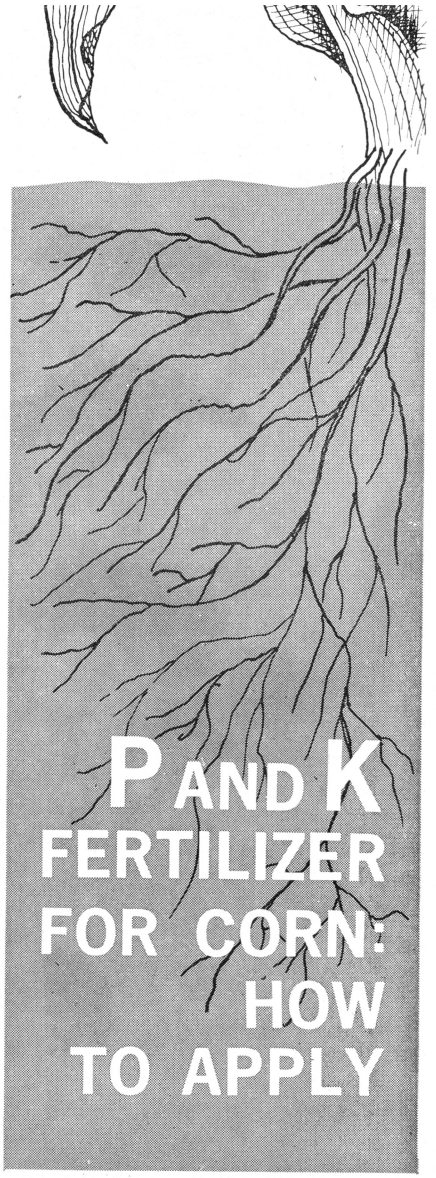

# P AND K FERTILIZER FOR CORN: HOW TO APPLY

**More Iowa corn acres could be fertilized with phosphorus and potassium. Both hill (row) and broadcast application have their place. Here's what research tells us about methods of application.**

***by Lloyd Dumenil, John Pesek, J. R. Webb and J. J. Hanway***

USE OF phosphorus (P) and potassium (K) fertilizers for corn in Iowa has increased in recent years but not as markedly as the use of nitrogen (N) fertilizer.

*More Iowa corn acres can be fertilized profitably with P and K.* And higher rates, particularly of P, can also be used profitably in all areas of the state.

Lack of P has limited corn yields more frequently in most areas recently than the lack of N and K (table 1). The corn leaf analyses (chemical analyses of leaves sampled at silking time) from sites selected at random in 15 Iowa counties in a recent research project show the nutrient status of the corn. These analyses show how well farmers at these sites matched fertility management and other management practices, such as stand, to the available nutrients in their soils for the weather conditions that occurred.

Lack of K limited corn yields more often in the till soils of northeastern Iowa than in other areas. Lack of N limited yields most frequently in the soil areas where available P and K were adequate or where use of N fertilizer has increased more slowly.

Single nutrient and multiple nutrient deficiences have varied markedly among our soils and even within the same soils due to differences in nutrient availabilities and in fertility management. Of the corn at the sites that had adequate nutrients, deficiencies (particularly of N) would have occurred more frequently if stands had been higher. These leaf analyses stress the need for much more soil testing in the state to get the proper balance of fertilizer nutrients for most profitable corn production.

## Application Methods . . .

Behavior of applied P and K fertilizer in the soil is similar. Unlike N in the nitrate form which moves with the soil water, P and K are held by the soil and move very little from the place of application, except in sands and loamy sands. The P and K in fertilizer also revert with time to less available forms. The rate and degree of reversion (fixation) depend mostly on chemical and physical properties of the fertilizers and soils and the degree of mixing of the two (method of application).

With *ideal* moisture conditions, banding of P and K should be the most efficient placement. The concentration of the readily available P and K in the band and surrounding soil remains high and thus is reverted more slowly to less available forms. In practice, placement in a band near the seed, as with the planter attachment, is frequently not the most efficient method. Drying of the soil around the fertilizer band often limits nutrient uptake. Also, our soils do not seriously "fix" P and K.

Three alternatives or methods of application of P and K are generally available: (1) all applied before planting (mostly broadcast before or after plowing), (2) all applied near the hill or along the row with a planter attachment, and (3) a combination of the two methods. Both agronomic advantages and economic factors (costs, time and labor) of the various method need to be considered.

Questions about most profitable methods arise mostly for soils testing *very low* and *low* in P or K or both. On these soils, most profitable rates per acre for corn vary from 18 to 70 pounds of P (40-160 pounds of $P_2O_5$) and 33 to 133 pounds of K (40-160 pounds of $K_2O$). For soils testing medium and high, optimum rates are usually less than 18 pounds of P and 33 pounds of K; hill or row application with a planter attachment usually has been the most profitable method on these soils.

Changes in methods of application have occurred recently (table 2). Methods of applying K closely parallel those of P except in western Iowa where most of the K has been applied in the row.

Recently, increased rates of P and K have been applied with the planter attachment, particularly in eastern Iowa. This is not apt to be the most profitable way to increase P and K rates except for hardground listed corn in western Iowa and possibly for continuous corn and on slowly drained soils in northeastern Iowa.

## Outlying Experimental Farms Tests . . .

Comparisons of plowed-under P with and without row-applied P were started in 1956 and 1957 at the Moody, Galva-Primghar, Clarion-Webster and Southern Iowa Experimental Farms. In 1963, the experiments were revised. Plowed-

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**TABLE 1. Nutrient status of corn as shown by leaf analyses, Corn Yield Study. (Center for Agricultural and Economic Development, Cooperative Extension Service and Soil Conservation Service, cooperating.)**

| County | Soil Area[1] | Percent of sites showing the following: | | | | |
|---|---|---|---|---|---|---|
| | | Nutrients adequate | Most limiting nutrient | | | Deficient in 2 or 3 nutrients |
| | | | N | P | K | |
| Harrison | MIH | 17 | 17 | 65 | 0 | 61 |
| | LOS | 50 | 38 | 12 | 0 | 38 |
| Woodbury* | MIH, GPS | 37 | 10 | 53 | 0 | 41 |
| | LOS | 40 | 50 | 10 | 0 | 20 |
| Crawford* | MIH, M | 38 | 28 | 34 | 0 | 38 |
| Cass* | M, SSM | 31 | 25 | 44 | 0 | 41 |
| Adams* | SSM | 39 | 22 | 39 | 0 | 35 |
| Lyon* | Mo, GPS | 46 | 3 | 49 | 2 | 48 |
| Clay | GPS, CNW | 21 | 13 | 58 | 8 | 66 |
| Hamilton | CNW | 24 | 17 | 54 | 5 | 54 |
| Howard | CLC | 19 | 26 | 42 | 13 | 74 |
| Bremer* | KFC | 35 | 18 | 18 | 29 | 53 |
| Fayette* | KFC, F | 22 | 37 | 25 | 17 | 68 |
| Linn* | KFC, DT, F | 41 | 14 | 28 | 17 | 52 |
| Muscatine | TM, F | 36 | 32 | 19 | 13 | 26 |
| Keokuk | OMT, CKL | 23 | 17 | 55 | 5 | 65 |
| Wayne | ASE | 18 | 19 | 52 | 11 | 70 |

[1]MIH: Monona-Ida-Hamburg; LOS: Luton-Onawa-Salix (Mo. bottomland); GPS: Galva-Primghar-Sac; M: Marshall; SSM: Shelby-Sharpsburg-Macksburg; Mo: Moody; CNW: Clarion-Nicollet-Webster; CLC: Cresco-Lourdes-Clyde; KFC: Kenyon-Floyd-Clyde; F: Fayette; DT: Dinsdale-Tama; TM: Tama-Muscatine; OMT: Otley-Mahaska-Taintor; CKL: Clinton-Keswick-Lindley; and ASE: Adair-Seymour-Edina.
*Sampled in 1961-1963; other counties sampled in 1962 and 1963.

**TABLE 2. Methods of P application used in recent years, Corn Yield Study.**

| County | Years | Percent of sites using | | | |
|---|---|---|---|---|---|
| | | P fertilizer | Broadcast P | Hill or row P | Both methods |
| Woodbury | 1959-1960 | 24 | 19 | 5 | 0 |
| | 1961-1962 | 44 | 30 | 13 | 0 |
| | 1963-1964 | 62 | 33 | 33 | 4 |
| Cass | 1958-1959 | 14 | 0 | 14 | 0 |
| | 1960-1961 | 34 | 14 | 20 | 0 |
| | 1962-1964 | 52 | 10 | 43 | 2 |
| Clay | 1958-1962 | 64 | 29 | 42 | 7 |
| | 1963-1964 | 78 | 27 | 65 | 14 |
| Hamilton | 1957-1960 | 40 | 24 | 20 | 4 |
| | 1961-1962 | 67 | 36 | 41 | 10 |
| | 1963-1964 | 86 | 51 | 57 | 23 |
| Bremer | 1958-1960 | 90 | 8 | 90 | 8 |
| | 1961-1964 | 93 | 15 | 91 | 13 |
| Keokuk | 1958-1961 | 25 | 14 | 11 | 0 |
| | 1962-1964 | 66 | 29 | 37 | 0 |
| Wayne | 1957-1961 | 47 | 11 | 40 | 4 |
| | 1962-1964 | 71 | 27 | 56 | 12 |

under P rates were increased slightly, and the row application was changed from P to a N-P-K fertilizer.

At both the Clarion-Webster and Galva-Primghar farms, the most profitable method of application for the high rate of P (most profitable for the rotation) has been plowed-under alone (table 3). For a moderate rate of P, the combination of row and plowed-under application was most profitable at the Clarion-Webster farm. Although row-applied P was profitable with the low rate of plowed-under P at the Galva-Primghar farm, the same increase could have been gotten by plowing under all of the P (27 pounds P total) as from the split application.

What has been the effect of the complete row fertilizer used in 1963 and 1964? Average yield increases from the row fertilizer and low rate of plowed-under P were 14 and 21 bushels, respectively, at the Clarion-Webster farm and 10 and 19 bushels, respectively, at the Galva-Primghar farm. The change in the row fertilizer has not changed the relative responses between the two methods to date. It only decreased the difference in cost between the two treatments.

In another experiment at the Galva-Primghar farm, P fertilizer is plowed under for first-year corn but is row-applied for both corn crops in a corn-corn-oats rotation. Total yield increases for the two years from plowed-under P has been more profitable than the row applied P or the combination (table 4).

Recent results from the Outlying Experimental Farms along with results from earlier experiments show that plowed-under P alone is more profitable than row application and is as profitable generally as the combination of plowed-under and row application on the *better drained* soils in the western half of the state.

## Hill or Row Application . . .

The side band planter attachment is rapidly replacing the older split boot attachment. Advantages of side band over split boot placement are: much less damage to germination, deeper placement, and somewhat more yield response — 3 bushels more from 150 pounds of 5-20-20 fertilizer in 7 experiments in 1957 to 1959.

*Advantages* of hill or row placement are:

1. Usually gives early growth response and increases leaf area and root development all of which increase the potential for increased later growth and yield. The "starter" effect often is visible in 7 to 10 days after emergence.

2. Gives largest growth responses on slowly to imperfectly drained soils, particularly when late May, June and early July are cool and wet.

3. Early growth response often permits corn to be cultivated earlier, easier and faster.

4. Hastens maturity up to 10 days, depending on weather, soil fertility and other fertilizer treatments. This is particularly important in northern Iowa. This *can* be a disadvantage if silking is moved into a hot, dry period.

5. Supplies nutrients for later growth, *if moisture is favorable.*

6. Usually most efficient methods for soils testing medium and high in P and K, for minimum recommended rates on many soils and for hard ground listed corn.

**TABLE 3. Yield increases of corn and of residual effects on oats and meadow from row-applied and plowed-under P fertilizer, Rock-Super Experiments, Clarion-Webster Experimental Farm, Hancock County and Galva-Primghar Experimental Farm, O'Brien County.**

| Treatment[1] (lbs. P per acre) | | Average yield increases (bu./A. or tons/A.)[2] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Clarion-Webster Farm[3] | | | Galva-Primghar Farm[4] | | |
| Plowed-under | Row | Corn | Oats | Meadow | Corn | Oats | Meadow |
| 0 | 9 | 13 | — | — | 6 | — | — |
| 18 | 0 | 21 | 14 | 0.6 | 10 | 5 | 0.3 |
| 18 | 9 | 27 | — | — | 14 | — | — |
| 35 | 0 | 24 | 25 | 1.5 | 16 | 10 | 0.8 |
| 35 | 9 | 26 | — | — | 16 | — | — |

[1] Treatments were applied to corn in a C-O-M rotation. In 1963, plowed-under rates were increased to 20 and 40 pounds of P (46 and 92 pounds of $P_2O_5$) and row application was changed to 115 pounds of 5-20-20 and 5-20-10 (oxide basis) at the CWEF and GPEF, respectively.
[2] Corn yields in 1957 to 1964, oat yields in 1958 to 1964 and meadow yields in 1959 to 1964.
[3] Soil type — Calcareous Webster (tiled). Soil tests — very low P and medium K.
[4] Soil type — Primghar. Soil tests — very low to low P and medium K.

**TABLE 4. Corn yield increases from row-applied and plowed-under P fertilizer in a C-C-O rotation. Time and rates of N and P Experiment, Galva-Primghar Experimental Farm, O'Brien County.**

| Treatment[1] (lbs. P per acre) | | Average yield increases (bu./A.)[2] | | |
|---|---|---|---|---|
| Plowed-under for first year corn only | Row-applied for each corn crop | First-year corn (1957-1964) | Second-year corn (1958-1964) | Total (2 years) ($C_1 + C_2$) |
| 0 | 9 | 8 | 9 | 17 |
| 18 | 0 | 19 | 10 | 29 |
| 18 | 9 | 22 | 19 | 41 |
| 35 | 0 | 25 | 16 | 41 |
| 35 | 9 | 27 | 18 | 45 |

[1] In 1963, plowed-under rates were increased to 20 and 40 pounds of P (46 and 92 pounds of $P_2O_5$) and row application was changed to 115 pounds of 5-20-10 (oxide basis). Soil type is Galva testing very low in P and medium in K.
[2] First-year corn comparisons are from treatments receiving 120 pounds N. Second-year corn comparisons are from those receiving 60 pounds N in each of the 2 years; lack of N, however, was limiting yields of second-year corn.

7. Practical method for applying higher rates of P and K for continuous corn, since most of residual or carryover from a previous application is in a plowed-under position.

8. Increases corn yields profitably over the years on most soils.

*Disadvantages* of hill or row placement are:

1. Availability of nutrients for early growth may be limited if May and June rainfall is low; thus early starter effect may be nil. Deeper placement may increase nutrient uptake if top few inches dries, but early starter effect will be delayed.

2. Location of band does not favor nutrient uptake in later growth stages. After wetting, area nearest the stalks is depleted of moisture first; the fertilizer thus may remain in dry soil much of the time. The dense leaf canopy and frequent ridging of the row by cultivation concentrates water from late June and July rains toward the mid-row.

3. Cultivation too deep and close to the row may decrease efficiency.

4. Often stimulates weed growth in the row since weeds also respond well to fertilizer.

5. May increase first brood borer infestation (since moths prefer to lay eggs on earliest planted, fastest growing corn in the area) and nullify the potential yield increase.

6. Slows planting but not nearly as much now as previously since new planters have large capacity fertilizer hoppers or tanks.

7. Yield responses have been quite variable, primarily due to seasonal differences in temperature and moisture. Responses often are low to nil in dry years.

8. Yield responses often decrease markedly as plowed-under rates of P and K are increased to most profitable levels. This behavior becomes more important as more farmers apply most profitable rates.

9. Profitability of amounts above 13 pounds of P and 25 pounds of K (30 pounds of $P_2O_5$ and $K_2O$) usually decreases sharply. Rates usually should be limited to 30 pounds of $P_2O_5$ and $K_2O$ (10-20 pounds if high rates of P and K have been plowed under).

## Pre-Plant (Broadcast) Application . . .

Most pre-plant applications of P and K are broadcast before or after plowing. Plowing under of P and K usually increases yields more than application after plowing (table 5). With plowed-under placement, the nutrients remain in contact with moist soil longer during dry weather and are mixed less with the soil than with disked-in placement. Growth response from broadcast placement, a "delayed starter" effect, becomes visible about 3 weeks after emergence.

*Advantages* of broadcast (plowed-under) are:

1. Usually is the most profitable method for applying *most* of the P and K on soils testing *very low* to *low* throughout the profile.

2. Usually is more profitable than row fertilizer on better drained soils very low and low in P in the western half of Iowa.

3. Usually more efficient than row fertilizer in dry seasons due to its deeper placement.

4. You can apply N along with P or K or both at one time. Rela-

**TABLE 5. Increases in corn leaf composition and yields from plowed-under and disked-in applications of P fertilizer.**

| Method | Average increase in leaf P (%) | Average yield[1] increase (bu./A.) |
|---|---|---|
| Plowed-under | 0.05 | 20 |
| Disked-in | 0.04 | 16 |

[1] Average of 16 experiments in 1952 to 1955. Average P rate — 28 pounds P (63 pounds $P_2O_5$).

tive costs of N and the soil properties determine whether N should be applied with the P and K or at a different time.

5. More uniform distribution of residual P and K than from row application for succeeding oats, meadow and possibly soybeans.

6. Hastens maturity, often markedly, since high rates are frequently applied on nutrient-deficient soils.

7. Can be applied conveniently in the fall before plowing. Plowing under in the fall usually increases yields more than disking in after plowing either in the fall or spring.

*Disadvantages* of broadcast application are:

1. Usually not as profitable as row application on soils testing medium and above in P and K and on soils testing somewhat lower in above normal moisture seasons.

2. Yield responses are more dependent on the N rate applied than are those from low to medium rates of row application. Since higher rates of P and K are usually broadcast, balance with N frequently is critical for most profitable increases.

3. The better method (plowed-under or disked-in) for a fertilizer-soil insecticide mix may be different for each material. Many have disked in this combination to get better rootworm control, but at the expense of P and K efficiency.

4. Disked-in materials containing N may increase weed growth.

5. Fertilizer applied on sloping land is vulnerable to erosion losses unless covered immediately. Winter application is more vulnerable to these losses.

## Combination of Methods . . .

Since the weather for the season cannot be predicted accurately, combining hill or row and plowed-under applications is most profitable for many soils.

A problem in the choice of methods frequently arises for those fields having moderate P and/or K deficiencies. It is hardly worth the time and labor to split the recommended rates of about 40 pounds of $P_2O_5$ and $K_2O$ between hill or row and plowed-under applications, unless N can be broadcast with the P and K. Usually, all the P and K will be applied by one method. An alternative for two years of corn is to apply hill or row fertilizer for each crop and to plow under a higher rate for first-year corn only.

## Other Methods . . .

Liquid or solid complete fertilizers may be banded before or after planting at various depths down to 6 to 7 inches. Deeply banded fertilizer should be applied after plowing to maintain the depth of application.

Although we have no research on this specific method, other research may give some clues about its behavior. Plow-sole placement of solid materials in bands 24 to 28 inches apart had no disadvantage compared with plowed-under placement in some early experiments. Injection of 13 pounds of P (30 pounds $P_2O_5$) per acre in liquid form near the hill as late as 3 to 4 weeks after emergence increased yields as much as application at planting time. Yield responses decreased sharply as application was delayed further. In these experiments placement was several inches to the side and about 2 inches below seed depth; the roots were not disturbed. *In practice, fertilizer placement after planting needs to be far enough from the row to not damage roots.*

Pre-plant banding, if placed deeply, probably is more efficient than disked-in but is no more efficient than plowed-under application. Banding shortly after planting, if placed 5 to 7 inches deep, may be as efficient as pre-plant application. But we don't know how late the application can be delayed and still be effective. If applied in bands 40 inches apart and in mid-row, uptake of P and K will be delayed somewhat longer than from plowed-under placement. Distance between the bands and rows will vary if applied pre-plant but can be controlled if applied after planting. Row application of low rates with a planter attachment may offset this delayed uptake by furnishing nutrients for early growth.

## Summary . . .

Recent data on methods of P application show that we should modify some of our recommendations for the better drained soils in the western part of the state. This area includes the Clarion-Nicollet-Webster and the Shelby-Sharpsburg-Macksburg soil areas and soil areas to the west of these two soil associations. In these areas, plowed-under P alone appears to be more profitable than hill or row application or the combination of methods on soils testing very low or low in P, particularly as rates increase to optimum levels. For rates less than optimum (most profitable), plowed-under P alone or the combination appears to be about equally profitable.

For the more poorly drained soils in the western soil areas, the combination of methods appears to be most profitable.

In the eastern half of the state, hill or row placement or the combination of hill or row and plowed-under application will be most profitable for most soils. For some of the well-drained soils, plowed-under placement alone will be nearly as profitable.

For many, some of the advantages and disadvantages other than yield responses may influence their selection of the method they will use.

Results from the early experiments show that the effects of K placement on yields are similar to those of P placement. Since K uptake by corn up to silking time occurs at a faster rate than either N or P uptake, hill or row placement probably is somewhat more important for K than for P.

In western Iowa where most of the soils test medium and high in K, the preferable method for K application is row placement. Because of the value of the K in the row fertilizer, use of low rates may be profitable even in combination with high rates of plowed-under P. On the other hand, the increased efficiency of row-applied K may be more than offset by the loss in efficiency due to application of part of the P in the row fertilizer. The experiments on the Outlying Experimental Farms will continue to give us information about this problem in western Iowa.